



Turbulence Detection & Mitigation Element

Weather Accident Prevention
Second Annual Review
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Briefing Outline

Organization

Scope of Turbulence Effort

Background

Turbulence Detection & Mitigation Program Metrics

Approach

Turbulence Team Relationships

WBS Structure

Deliverables

TDAM Changes

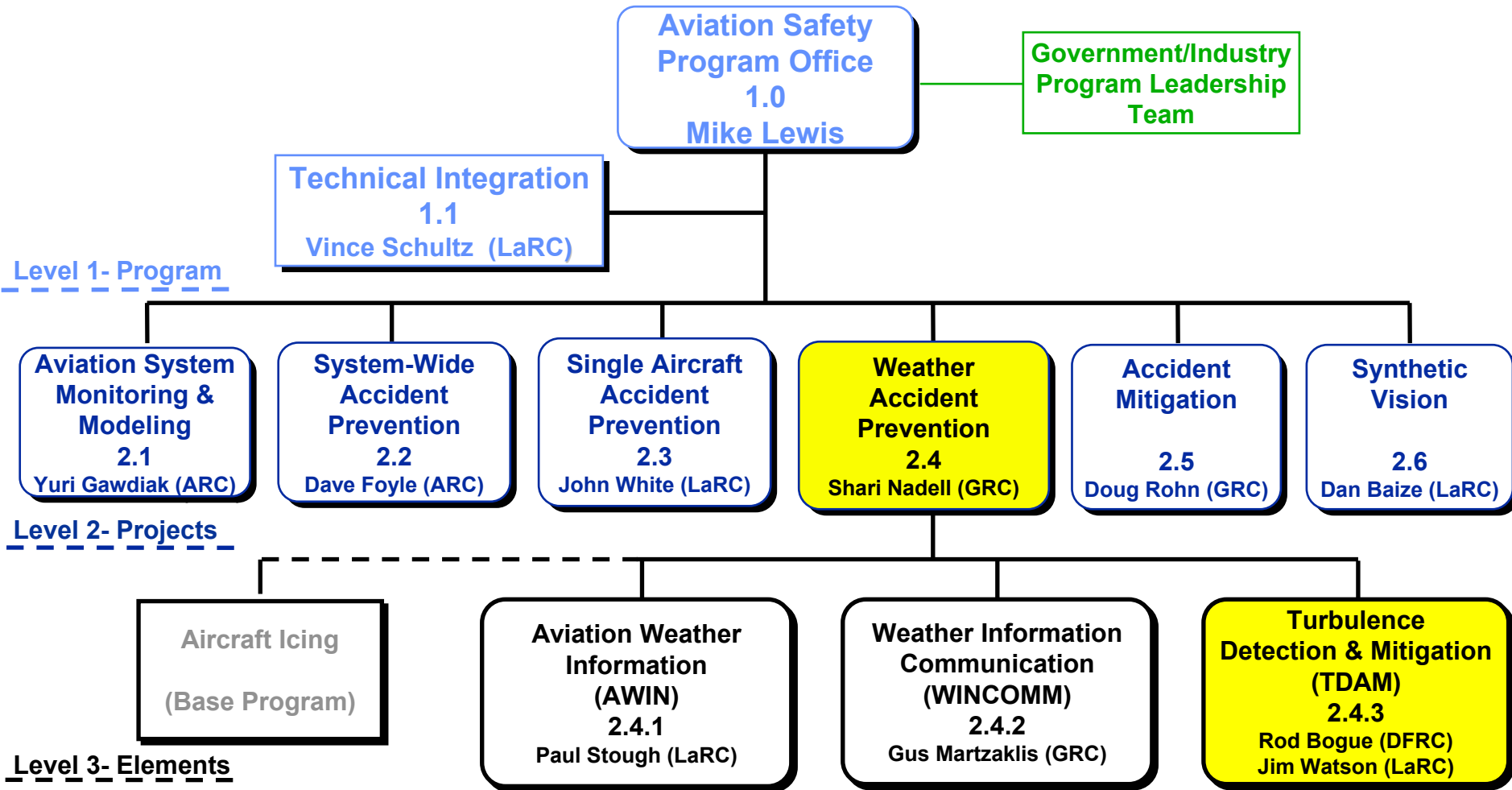
FY-01 Results/Accomplishments

Out-year Plans

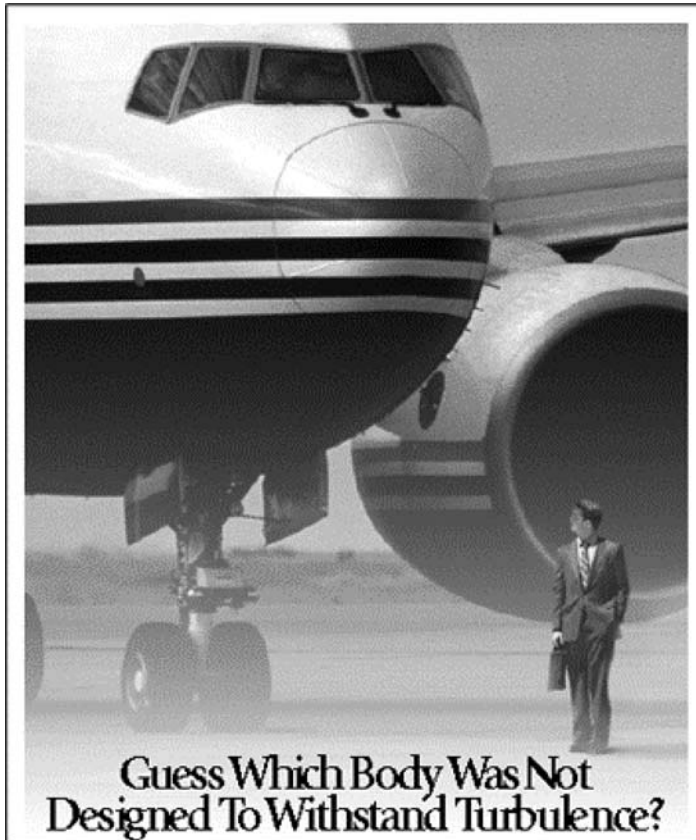
Element Status



Aviation Safety Program Organization



Scope of Turbulence Effort



- Turbulence from Natural Atmospheric Processes
- Parts 121, and 91 (Scheduled Carriers, Commuters & GA)
- Tactical (Enroute)
- Both Avoidance & Encounter Mitigation*↓
- Flight Deck Integration*↑

Note:*↓ = Reduced effort, *↑ = Starting effort.



Background

- Turbulence Costs
 - Primary Cause of In-Flight Injuries (9 encounters/24 injuries per month)
 - Cost estimated at >\$100M/yr. for airlines
- Turbulence Initiators
 - Convective Storms (within and as far as 40 miles away from visible clouds in clear air)
 - Jet Stream (at confluence of multiple streams and near boundaries)
 - Mountain Wave (upward propagating from disturbances near the surface)

Turbulence Detection & Mitigation Program Metrics

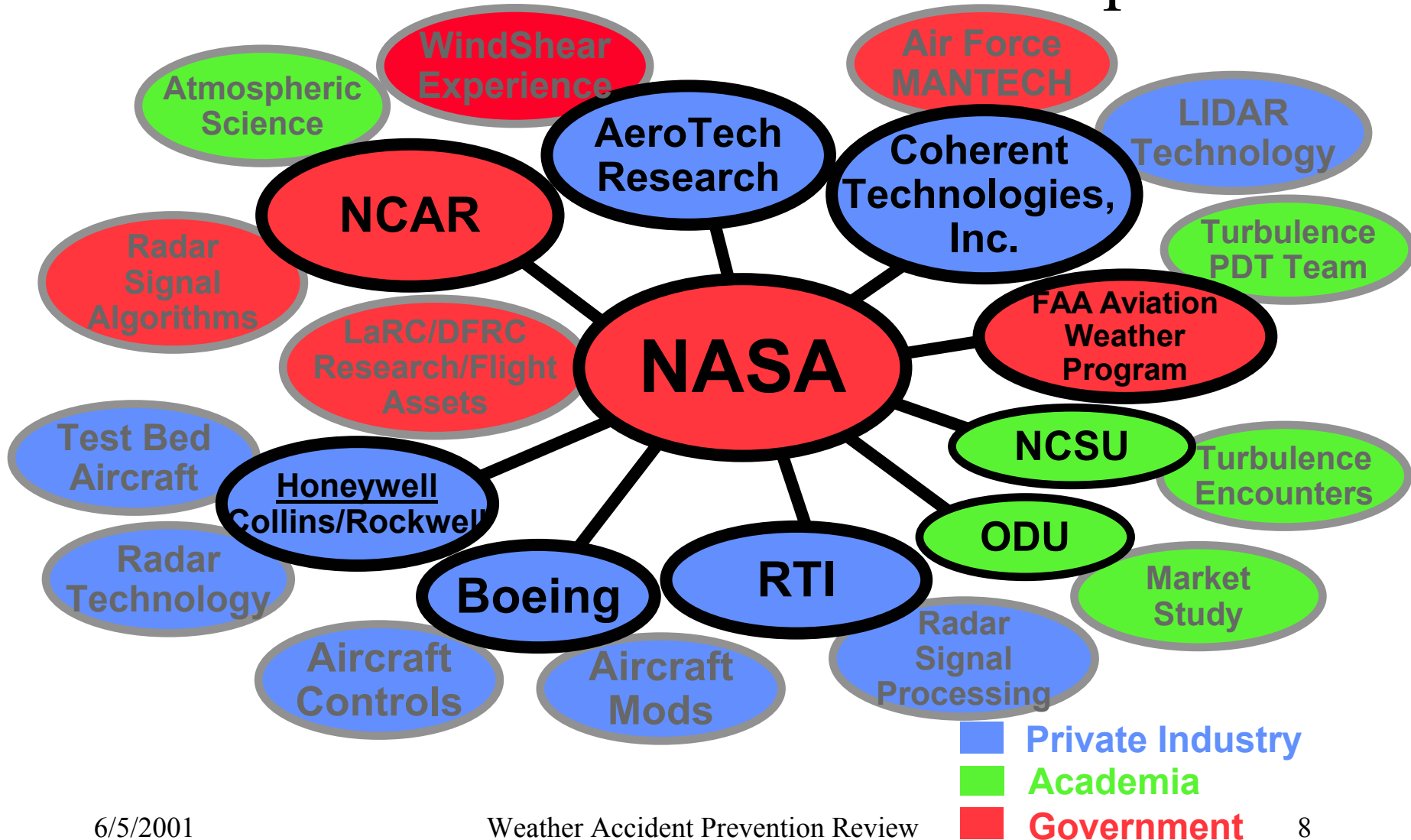
- **WxAP Objective # 3:** Provide commercial aircraft sensor with 90% probability of detection of severe Convective and Clear Air Turbulence thirty seconds to two minutes before encounter.
- **WxAP Milestone #2:** Flight demonstrate certifiable forward-looking on-board turbulence warning system with Type-I and Type-II error probability commensurate with airborne wind shear technology (TRL/IRL of 7/4)



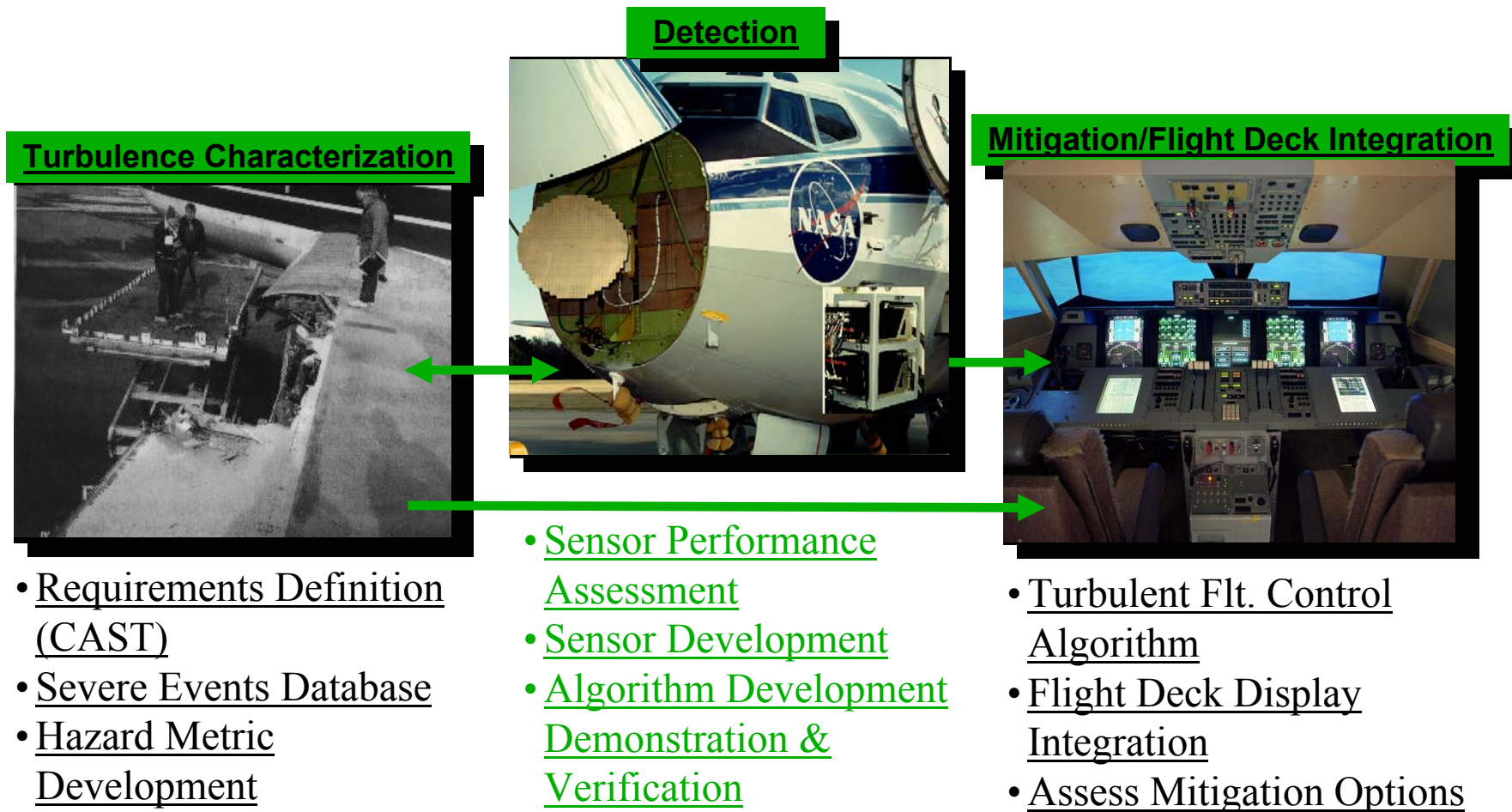
Approach

- Build a Turbulence Team from Industry, Academia, and Government to address requirements, approaches, and solutions
- Utilize the Commercial Aircraft Safety Team (CAST) to determine requirements for Air Carriers (<http://www.cygnacom.com/turbulence/>)
- Address Air Carrier Issues with Technology Approaches with assistance from FAA Rule-Making, and Improved Procedures
- Address GA Issues with improved Weather Products Disseminated through Aviation Weather INformation

Turbulence Team Relationships



WBS Structure





Major Deliverables/Products

- Turbulence Characterization
 - Validation of In-situ Algorithm
 - Turbulence Hazard Metric
- Detector Technology
 - Radar (software)
 - Lidar (hardware/software)
- Encounter Mitigation Technology
 - Assessment of Conventional Aircraft Control Authority
- Flight Deck Integration
 - Display Integration



Element Changes

- Program Changes
 - Elimination of Forecasting/Nowcasting WBS
 - De-scope of Mitigation
 - Initiation of Flight Deck Integration
- Staffing Changes
 - Level III Deputy
 - Bruce Kendall - interim
 - Jim Watson
 - Level IV
 - Neil O'Connor - Turbulence Characterization Lead
 - Robert Neece - Detection & Mitigation Lead
 - Phil Schaffner - Radar Principal Investigator
 - Ivan Clark & Phil Gatt - Lidar Co-principal Investigators

Element Accomplishments

- Turbulence Characterization & Sensor Development
 - Research Radar Flight Experiments
 - 3 Flights (15 hours)
 - Predicted atmosphere along flight path
 - Verified turbulence in-situ algorithms
 - Established relationship between rms aircraft g-load and radar observables
 - CDR for B-757Lidar Installation
- Radar Flight Sensor Certification/Flight Deck Integration
 - Participated in NASA-FAA-Industry Workshops (3) for Forward Looking Turbulence Sensor Certification*
 - Selected and modeled 4 turbulence encounters for candidate sensor verification & certification

Note: * indicates item will not be covered later in detail



Element Accomplishments (cont.)

- Turbulence Mitigation
 - Flight Control Report (Boeing)
 - Phase 2 SBIR for Feedforward Active Encounter Mitigation (CTI)*
- Guidance Activities
 - Commercial Aviation Safety Team
 - Completed Turbulence Joint Safety Assessment Process (30 Interventions - Technology Development, Procedures, Training)
 - Chartered Turbulence Joint Safety Implementation Process
 - Prioritized Interventions - Selected for Implementation
 - Developed Projects - Identified Outputs
 - Secure Cabin Exercise
 - Established Team - FAA (CAMI), Airlines (5), Flight Attendant Organizations(2), ARI Consultant
 - Exercise Planning in Progress

Element Plans

- Turbulence Characterization & Sensor Development
 - Research Radar Flight Experiments with real-time Radar Algorithm in operation (Early FY-02 and Late FY-02)
 - Research Lidar Flight Experiments (Summer FY-01 on DC-8, Later FY- 02 on B757)
- Radar Flight Sensor Certification
 - Support NASA-FAA Certification Team effort with flight tests and algorithm validation activities
 - Continue analysis of turbulence encounters for sensor verification & certification



Element Plans (cont.)

- Turbulence Mitigation
 - Flight Control Assessment (Boeing)
 - Support Phase 2 SBIR for Feed-forward Active Encounter Mitigation
- Commercial Aviation Safety Team
 - Complete Turbulence Joint Safety Implementation Process
 - Refine Projects and Outputs
 - Transition Projects to CAST Management
- Secure Cabin Exercise
 - Conduct wide-body exercise at CAMI in September 01
 - Develop Plans and conduct narrow-body exercise in FY-02





Summary - Status of Elements

- Turbulence Characterization
 - Accident analysis developing robust cases for certification
 - Developing turbulence weather analysis models
- Detection
 - Radar flight tests in December provided promising results for detecting turbulence in the vicinity of convective activity
 - Lidar flight tests in FY-01 expected to confirm/validate performance at cruise altitude
- Encounter Mitigation
 - Promising assessment of mitigation control options
- Flight Deck Integration
 - Planning for display integration with NASA-FAA Certification Team



Supplementary Charts

For supporting questions

Model for Reducing Air Carrier Turbulence Accident Rate

